



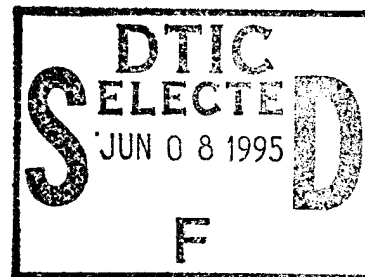
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TECHNICAL REPORT
NATICK/TR-95/005

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THE DEVELOPMENT OF A COMMERCIAL RATION FOR OPERATION DESERT STORM

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November 1994

FINAL REPORT
January 1991 - January 1993

Approved for Public Release;
Distribution Unlimited

19950605 034

UNITED STATES ARMY NATICK
RESEARCH, DEVELOPMENT AND ENGINEERING CENTER
NATICK, MASSACHUSETTS 01760-5000

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| REPORT DOCUMENTATION PAGE | | | Form Approved OMB No. 0704-0188 | |
|--|--|--|--|---|
| Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503. | | | | |
| 1. AGENCY USE ONLY (Leave blank) | | 2. REPORT DATE November 1994 | | 3. REPORT TYPE AND DATES COVERED Final: Jan 91 - Jan 93 |
| 4. TITLE AND SUBTITLE The Development of a Commercial Ration for Operation Desert Storm | | | 5. FUNDING NUMBERS WV-53121CP120Z00 | |
| 6. AUTHOR(S) Judith M. Aylward, Brooke E. Cheema, M. Susan Harrington | | | | |
| 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) U.S. Army Natick Research, Development and Engineering Center ATTN: SATNC-WRD Kansas Street Natick, MA 01760 | | | 8. PERFORMING ORGANIZATION REPORT NUMBER NATICK/TR-95/005 | |
| 9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) | | | 10. SPONSORING/MONITORING AGENCY REPORT NUMBER | |
| 11. SUPPLEMENTARY NOTES | | | | |
| 12a. DISTRIBUTION/AVAILABILITY STATEMENT Approved for Public Release; Distribution Unlimited | | | 12b. DISTRIBUTION CODE | |
| 13. ABSTRACT (Maximum 200 words) During Operation Desert Shield/Storm, a potential problem in the logistical system was revealed. Although the Armed Forces maintain a limited prepositioned war reserve stock for use in emergencies, this supply was taxed to subsist the large number of troops in Southwest Asia, until the military ration manufacturers could scale up to meet this requirement. As a result, the Meal, Ordered Ready-to-Eat (Contingency Test) (MORE (CT)), which utilizes commercially available products, was developed. This consists of a commercial food data base and a packaging document which will facilitate the procurement and distribution of subsistence items to alleviate potential shortfalls in the event of emergency war mobilization. | | | | |
| 14. SUBJECT TERMS COMMERCIALLY AVAILABLE OPERATION DESERT STORM RATIONS MORE (MEAL, ORDERED READY-TO-EAT) MORE-MF (MEAL, ORDERED READY-TO-EAT, MULTI FAITH) | | | 15. NUMBER OF PAGES 29 | |
| | | | 16. PRICE CODE | |
| 17. SECURITY CLASSIFICATION OF REPORT UNCLASSIFIED | | 18. SECURITY CLASSIFICATION OF THIS PAGE UNCLASSIFIED | | 19. SECURITY CLASSIFICATION OF ABSTRACT UNCLASSIFIED |
| | | | | 20. LIMITATION OF ABSTRACT SAR |

CONTENTS

| | |
|---------------------------------|-----|
| List of Figures and Tables..... | v |
| Preface..... | vii |
| Introduction..... | 1 |
| Methods..... | 5 |
| Results..... | 8 |
| Discussion..... | 12 |
| Conclusions/Implications..... | 16 |
| References..... | 21 |

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| Unannounced | <input type="checkbox"/> |
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LIST OF FIGURES AND TABLES

| <u>Figures</u> | <u>Page</u> |
|---|-------------|
| 1. Meal, Ordered Ready-to-Eat (Contingency Test) Menus.... | 11 |
| 2. Meal, Ordered Ready-to-Eat, Multi-Faith Lacto-Ovo Vegetarian Menus..... | 13 |
| 3. Meal, Ordered Ready-to-Eat, Multi-Faith Kosher Menus... | 14 |

Table

| | |
|---|---|
| 1. Nutritional Standards for Operational Rations..... | 2 |
|---|---|

PREFACE

The Meal, Ordered Ready-to-Eat (Contingency Test), which utilizes commercially available products, was developed during Operation Desert Shield/Storm to supplement military rations and avoid potential shortfalls in feeding a large number of troops until the ration manufacturers could scale-up production. As a result of this effort, the Go-to-War ration was established. The Ration consists of (a data base) commercial foods readily available for procurement and a packaging and assembly document to facilitate distribution during emergency war mobilization.

The authors wish to thank all of the food technologists from the Sustainability Directorate who participated in the numerous sensory evaluation panels conducted throughout the development of the Meal, Ordered Ready-to-Eat (Contingency Test). This report covers the period January 1991 to January 1993.

**THE DEVELOPMENT OF COMMERCIAL MILITARY RATION
FOR OPERATION DESERT STORM**

Introduction

The Sustainability Directorate of the U.S. Army Natick Research, Development and Engineering Center (Natick) in Natick, Massachusetts, is responsible for the design and development of military rations for the Armed Forces (Army, Air Force, Navy and Marines).

Operational rations are used to sustain individuals during military operations in the field, including combat and training exercises. All rations must be shelf stable for a minimum of three years at 27°C and six months at 38°C, easily prepared, highly acceptable, and nutritionally adequate, based on the Military Recommended Dietary Allowances (MRDAs) as shown in AR40-25, Nutritional Standards for Operational Rations (Table 1) (1). In addition, ration packaging must meet specific durability requirements in order to withstand the rigors of military handling.

Two of the standard operational rations used by the Armed Forces are Meal, Ready-to-Eat, Individual (MRE) and the Tray Ration. The MRE was fielded in the early 1980's. It is packaged in flexible, trilaminate pouches and provides approximately 1300 kilocalories (kcal) per meal. Each ration

Table 1.
Nutritional standards for operational rations (1)*

| Nutrient | Unit | Operational rations** |
|---------------|-------|-----------------------|
| Energy | kcal | 3600 |
| Protein | gm | 100 |
| Carbohydrate | gm | 440 |
| Fat | gm | 160(maximum) |
| Vitamin A | mcgRE | 1000 |
| Vitamin D | mcg | 10 |
| Vitamin E | mgTE | 10 |
| Ascorbic Acid | mg | 60 |
| Thiamin | mg | 1.8 |
| Riboflavin | mg | 2.2 |
| Niacin | mgNE | 24 |
| Vitamin B6 | mg | 2.2 |
| Folacin | mcg | 400 |
| Vitamin B12 | mcg | 3 |
| Calcium | mg | 800 |
| Phosphorus | mg | 800 |
| Magnesium | mg | 400 |
| Iron | mg | 18 |
| Zinc | mg | 15 |
| Sodium*** | mg | 5000-7000 |
| Potassium | mg | 1875-5625 |

* The operational ration includes the MRE, A, B, and T rations.

**Values are minimum standards at the time of consumption unless shown as a range or a maximum level.

***These values do not include salt packets.

contains a thermally-processed entree, a cracker, a variety of spreads, fruit, desserts, commercial candy, and several beverages. While the MRE is designed to feed the individual, the Tray Ration is designed to provide a hot meal to groups of military personnel. The Tray Ration provides approximately 1200 kcal per meal, consisting of an entree, starch, vegetable, dessert and beverages. It is packaged in sealed, half-steam-table-sized cans that may be immersed in hot water for heating and served from the same container. Whenever possible, supplements of fresh bread, fruit, vegetables and milk are supplied to increase variety and provide additional nutrients. On a typical day, the soldiers receive two hot group meals such as the Tray Ration and one MRE, which may be heated with the Flameless Ration Heater. The Flameless Ration Heaters are now available in bulk packs through the Federal Supply System and shortly will be incorporated into the MRE.

Due to the rapid and immense build up of troupes in Southwest Asia for Operation Desert Shield/Storm (ODS), available supplies of field rations were taxed to meet operational needs. Although for use in emergencies, the required quantities have never been procured due to the expense and difficulty in rotating stocks. In addition, due to the time required by industry to ramp up production quantities (three to six months), potential

production shortfalls were identified. Consequently, a request was submitted by the U.S. Army Quartermaster Center and School(QMC&S) for a ration consisting of individual serving, shelf stable, prepared commercial items to augment the existing ration system. In response to this request, the Meal, Ordered Ready-to-Eat, Contingency Test, MORE (CT), was developed at Natick.

In addition, the Armed Forces Chaplain Board identified a need for a ration designed for individuals with specific religious dietary requirements or special food preferences, such as Jews, Moslems, Buddhists, Hindus, Seventh-Day Adventists and vegetarians. Very few such individuals make the military a career, but more significant numbers are in the reserves (which were heavily represented in ODS). Unlike peacetime field training exercises where specialty foods can be obtained by soldiers requiring them, during ODS this was not possible. This lead to the development of the Meal, Ordered Ready-to-Eat, Multi-Faith of MORE-MF which consists of lacto-ovo vegetarian and Kosher/Hallal menus that meet a broad spectrum of religious food preferences.

The requirements for the MORE rations state that they must be: commercially available, individual serving size, easy-to-open, shelf stable, require minimum preparation and meet one third of the MRDAs. The names of the manufacturers and the

products evaluated have been omitted from this report to maintain confidentiality.

Methods

The development of the MORE rations included a literature search and market survey, product testing and evaluation, thermophilic microbiological study, menu design and nutritional analysis.

Literature Search and Market Survey

To identify commercial products currently available, a literature search was conducted of food processing publications, food trade and dietetic journals. To identify commercially available Kosher products, a solicitation specifying the MORE-MF requirements was placed in the Kosher magazine, Kashrus

(2). Additional information was obtained from several Rabbis, the Kashruth Food Guide, and Kosher food conference.

(3). A market survey of various supermarket chains was conducted and products were purchased for testing. Food manufacturers were contacted for samples, nutritional data, packaging specifications, and procurement information. A computer data base program was established to compile product information, serve as a tool for menu design and as a

procurement aid for the Defense Personnel Support Center (DPSC), the subsistence procurement agency for the Department of Defense.

Product Testing and Evaluation

Products were subjected to an initial sensory evaluation, a packaging integrity assessment, an accelerated high temperature storage study and a final sensory evaluation.

A panel of food technologists, which included military personnel, conducted the initial sensory evaluation. Sensory characteristics, including appearance, odor, flavor, texture, and overall quality were evaluated for each item. Due to the large quantity of products and the urgency of ODS, the evaluation process was confined to "accept" or "reject" parameters based on these sensory attributes.

The seal integrity of entrees and soups, packaged in polymeric trays and cups, was tested by immersing the containers into boiling water to approximate heating methods used during ODS.

Products that failed the initial evaluations were eliminated from further testing. Products passing the initial screening underwent an accelerated high temperature storage test in their original packaging. The accelerated storage studies were conducted to determine product/package stability at high temperatures, similar to those experienced in ODS. Sustained

high-temperature storage can result in deterioration of carbohydrates, proteins and lipids by nonenzymatic browning. In addition, if oxygen permeates the packaging, this may result in accelerated oxidative or hydrolytic rancidity (4). These reactions will adversely affect the sensory characteristics and nutrient content of foods (4). Test samples were stored at 49°C for 2 and 4 weeks to approximate high desert temperatures, while controls were stored at 27°C for the same duration. After storage, the products were evaluated by food technologists, using the sensory parameters previously mentioned and a commercial product evaluation form designed for this purpose. Eight sensory evaluation panels, four products per panel, were held daily for a period of five months.

Thermophilic Microbiological Study

To determine the presence of heat-resistant bacterial spores, of public health or food spoilage significance, a thermophilic microbiological study was conducted on the thermally processed entrees and soups by the Biohazard Assessment Branch, Natick (6). This study was conducted because these foods may contain heat-resistant spores capable of growth between 40° and 60° C, representing temperatures experienced in desert environments (5). The products were tested for the presence of thermophilic microorganisms after storage for 1 month at 49°C.

Menu Design and Nutritional Analysis

Product selection for the MORE (CT) and MORE-MF menus was based on the sensory evaluation, nutrient composition, menu compatibility, product availability, and ration requirements. All menus were designed to provide one third of the MRDAs and contain an entree, soup, fruit, snack or dessert, and beverages. Furthermore, all Kosher menus were developed to meet the Jewish Dietary Laws in the Kashruth Food Guide (3).

A nutrient analysis computer program with a United States Department of Agriculture (USDA) nutrient database of 2000 food items was utilized. Nutrient information for the commercial products was obtained from the food manufacturers and added to the database.

Results

Literature Search and Market Survey

Over 1300 food products representing entrees, starches, soups, fruits, desserts, snacks and beverages were received from about 300 food manufacturers. The manufacturer's name, address, point of contact, telephone number, product name, food category, weight, packaging information and storage evaluation results were entered into the database. To expand the procurement base and minimize potential shortfalls in product availability,

a listing of at least three alternative food manufacturers producing similar menu components was provided to the DPSC.

Product and Panel Evaluation

Thirteen hundred commercial products were evaluated by Natick's food technologists. Approximately 107 (8%) were rejected. Three percent of these were rejected initially due to poor quality or inadequate packaging, and five percent were rejected after high temperature storage due to unacceptable appearance, texture, off flavors and/or odors. Three hundred and fifty two of the food products tested were found to meet the requirements for the MORE MF. Of these, 41 (12%) were rejected due to inadequate packaging or poor sensory quality.

Thermophilic Microbiological Study

Five hundred and five commercial, thermally-processed entrees or soups were evaluated for heat resistant bacterial spores (6). Three entrees contained in trilaminate flexible pouches, from one manufacturer, had prominent soft and hard swells as well as package seam separation. Under direct microscopic examination, sporeforming short to medium long rods were observed in all three samples. In addition to the above, one product packaged in a trilaminate flexible pouch, with no

observed swelling, did contain gram positive sporeforming rods (6). Six commercially produced canned items had marked hard swells and were analyzed immediately. The samples tested negative for thermophiles, but corrosion within the cans may have accounted for the swells. Twelve commercially produced polymeric tray entrees had noticeable openings at the foil lid seal. Further analysis of these samples found no microbial growth. However, due to the lack of seal integrity, this line of entrees in polymeric trays was rejected.

Based on the microbiological criteria, a total of 25 products was rejected. However, this was traced to manufacturing problems and/or defective packaging and was not due the presence of heat-resistant spores or inadequate thermal processing.

Menu Design and Nutritional Analysis

Twelve MORE (CT) menus were developed and approved by the Office of the Surgeon General (Figure 1). Each menu consists of an entree, soup, fruit, snack or dessert, an instant dairy shake, coffee, non-dairy creamer, sugar, and a beverage base. The entrees are shelf stable, thermally processed, and packaged in polymeric trays or trilaminate flexible pouches. The ready-to-eat soups and fruits are packaged in pull-top cans or polymeric cups. Snacks and dehydrated beverages are packaged in

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|-------------------|---|---|--|---|--|--|---|---|---|---|--|--|
| ENTREE | LASAGNA | SW & SOUR CHIX/VEG RICE | BEEF STEW | CHILI CON CARNE BEEF/RICE | BEEF PEPPER STEAK/RICE | SPAGHETTI MEAT SCE | CHIX/VEG POT | SALISBURY STEAK/POT GRAVY | ORIENTAL CHICKEN/ RICE | ROAST BEEF POT/VEG | GL CHIX BREAST/ VEG/POT | POT ROAST VEG/POT |
| STARCH/ SOUP | CHIX NOODLE | VEGETABLE | SCALLOPED POT&HAM | BEEF NOODLE | CHIX NOODLE | VEGETABLE | MAC&CHEESE | VEGETABLE | BEEF NOODLE | CHIX NOODLE | MAC&CHEESE | VEGETABLE |
| VEG/ FRUIT | PEACHES | FRUIT CUP | PEARS | FRUIT CUP | APPLESAUCE | PEACHES | PEARS | CINNAMON APPLESAUCE | FRUIT CUP | PEARS | FRUIT CUP | PEACHES |
| DESSERT/ SNACK | FIG COOKIE BEEF JERKY OYSTER CRACKERS | CHOC CHIP COOKIES OYSTER CRACKERS | CHOC CANDY BAR | CHOC CHIP GRANOLA BAR OYSTER CRACKERS | CHOC CANDY BAR OYSTER CRACKERS | CANDY COATED CHOCOLATE OYSTER CRACKERS | OATMEAL COOKIE BEEF JERKY | CHOC CANDY BAR OYSTER CRACKERS | CINNAMON GRANOLA BAR OYSTER CRACKERS | CANDY COATED CHOCOLATE OYSTER CRACKERS | OAT&HONEY GRANOLA BAR OYSTER CRACKERS | CREAM FILLED COOKIE BEEF JERKY OYSTER CRACKERS |
| BEVERAGE | MILKSHAKE COFFEE CREAMER SUGAR HOT CHOC | MILKSHAKE COFFEE CREAMER SUGAR HOT CHOC | MILKSHAKE COFFEE CREAMER SUGAR FRUIT BEV | MILKSHAKE COFFEE CREAMER SUGAR HOT CHOC | MILKSHAKE COFFEE CREAMER SUGAR FRUIT BEV | MILKSHAKE COFFEE CREAMER SUGAR LEMON TEA | MILKSHAKE COFFEE CREAMER SUGAR HOT CHOC | MILKSHAKE COFFEE CREAMER SUGAR HOT CHOC | MILKSHAKE COFFEE CREAMER SUGAR HOT CHOC | MILKSHAKE COFFEE CREAMER SUGAR HOT CHOC | MILKSHAKE COFFEE CREAMER SUGAR FRUIT BEV | MILKSHAKE COFFEE CREAMER SUGAR HOT CHOC |
| SUPPLE- MENT | MILK BREAD FRUIT | MILK BREAD FRUIT | MILK BREAD FRUIT | MILK BREAD FRUIT | MILK BREAD FRUIT | MILK BREAD FRUIT | MILK BREAD FRUIT | MILK BREAD FRUIT | MILK BREAD FRUIT | MILK BREAD FRUIT | MILK BREAD FRUIT | MILK BREAD FRUIT |

Figure 1. Meal, Ordered Ready-to-Eat (Contingency Test) Menus

cellophane or foil material.

The MORE (CT) provides 1242 kcals, with 61% of the kcals from carbohydrates, 16% from protein, and 23% from fat. When supplemented with shelf stable bread, fruit and ultra-high temperature (UHT), aseptically packaged milk, the MORE (CT) meets one third of the MRDA's for all nutrients except iron (94%).

The lacto-ovo vegetarian and Kosher MORE-MF menus follow the design of the MORE (CT). Four Vegetarian and 10 Kosher menus were developed (Figures 2 and 3). Each menu consists of an entree, hearty soup, crackers or breadsticks, fruit, snack, dessert, a beverage powder, coffee, non-dairy creamer, and sugar.

All of the Kosher menus meet the Jewish Dietary Laws (3), and both the Vegetarian and Kosher menus meet one third of the MRDAs for all nutrients. The Vegetarian menus provide 1277 kcals, with 68% of the kcals from carbohydrates, 13% from protein and 19% from fat. The Kosher menus provide 1255 kcal, 59% from carbohydrate, 13% from protein and 28% from fat.

Discussion

To meet caloric and nutrient requirements, additional snacks and beverages are included in both the MORE (CT) and MORE-MF menus. Canned fruits provide a source of vitamins A and C. The

| | 1 | 2 | 3 | 4 |
|-----------|--|--|--|--|
| ENTREE | ROTINI PRIMAVERA | CHEESE TORTELLINI | PASTA SALAD | CHEESE RAVIOLI |
| SOUP | MINESTRONE | VEGETABLE | TOMATO | VEGETABLE |
| STARCH | BREADSTICK | BREADSTICK | BREADSTICK | BREADSTICK |
| FRUIT/VEG | PEACHES | FRUIT CUP | PEARS | CIN. APPLE SAUCE |
| SNACK | GRANOLA BAR VAN PUDDING | CEREAL BAR CHOC FDGE PUD. | GRANOLA BAR VAN PUDDING | CEREAL BAR BANANA PUDDING |
| DESSERT | BROWNIE | CHOCOLATE COVERED RAISINS | CHOC CHP COOKIE | CHOCOLATE COVERED RAISINS |
| BEVERAGES | COFFEE NONDAIRY CREAMER SUGAR HOT CHOC | COFFEE NONDAIRY CREAMER SUGAR HOT CHOC | COFFEE NONDAIRY CREAMER SUGAR HOT CHOC | COFFEE NONDAIRY CREAMER SUGAR HOT CHOC |

Figure 2. Meal, Ordered Ready-to-Eat, Multi-Faith
Lacto-Ovo Vegetarian Menus

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|----------|--|---|---|--|---|--|---|--|--|--|
| ENTREE | SALMON | TUNA | FISH STEAKS MUSTARD SCE | TURKEY MEATBALLS | VEGETARIAN PRIME STEAKS | CHICKEN | VEGETARIAN BEANS | KIPPERS | LASAGNA | SALISBURY STEAK |
| SOUP | CHIX/VEG/RICE | LENTIL | MUSH/BARLEY | VEGETABLE | TOMATO | MINESTRONE | MUSH/BARLEY | MINESTRONE | VEGETABLE | TOMATO |
| STARCH | MATZO CRACKER | SALTINES | BREADSTICKS | OYSTER CRACKERS | OYSTER CRACKERS | BREADSTICKS | CHEZ/PB CRACKE | MATZO CRACKER | BREAD STICKS | OYSTER CRACKERS |
| FRUIT | FRUIT CUP | PEACHES | TROPICAL FRUIT MIX | PEARS | RAISINS | FRUIT CUP | PEACHES | PRUNES | PEARS | FRUIT CUP |
| SNACK | CEREAL BAR | GRANOLA BAR CHOC PUDDING | GRANOLA BAR YOGURT CUP | CEREAL BAR APPLE CHIPS | CEREAL BAR VANILLA PUDDING | GRANOLA BAR | YOGURT CUP | PB CRACKERS CHOC PUDDING | GRANOLA BAR POP CORN | CEREAL BAR APPLE CHIPS |
| DESSERT | CHOC CHIP COOKIE | CHOC COATED RAISINS | CANDY COATED CHOCOLATE | FIG COOKIE | CANDY COATED PEANUTS | FIG COOKIE | BROWNIE | OATMEAL COOKIE | FIG COOKIE | OATMEAL COOKIE |
| BEVERAGE | FRUIT BEVERAGE COFFEE NONDAIRY CREAMER SUGAR | HOT CHOCOLATE COFFEE NONDAIRY CREAMER SUGAR | HOT CHOCOLATE COFFEE NONDAIRY CREAMER SUGAR | FRUIT BEVERAGE COFFEE NONDAIRY CREAMER SUGAR | HOT CHOCOLATE COFFEE NONDAIRY CREAMER SUGAR | FRUIT BEVERAGE COFFEE NONDAIRY CREAMER SUGAR | HOT CHOCOLATE COFFEE NONDAIRY CREAMER SUGAR | FRUIT BEVERAGE COFFEE NONDAIRY CREAMER SUGAR | FRUIT BEVERAGE COFFEE NONDAIRY CREAMER SUGAR | FRUIT BEVERAGE COFFEE NONDAIRY CREAMER SUGAR |

Figure 3. Meal, Ordered Ready-to-Eat, Multi-Faith Kosher Menus

beverages help to increase fluid consumption. The commercial dehydrated fruit flavored beverage is fortified with vitamin C (10 percent of the MRDA). The Instant Dairy Shake is a new commercial product that was originally developed as part of the Dental Liquid Ration for patients who cannot chew or swallow solid food. It is calorically dense (415 kilocalories) and is an excellent source of calcium (630 mg). This unique dehydrated powder, available in six flavors (three of which were used in the MORE (CT) rations) can be rehydrated instantly with water in its zip-lock foil pouch.

Shelf stable Kosher and vegetarian foods are not as widely available as more conventional commercial shelf stable foods. Therefore, it was more challenging to meet nutrient requirements in the MORE-MF menus. Furthermore, all Kosher foods must meet the Jewish religious dietary laws and carry a Kashruth symbol on their packaging labels (3,7). In addition, meat and poultry must be processed and consumed separately from dairy products. Thus, only a limited number of manufacturers have the facilities required to produce both Kosher and regular commercial, shelf stable products. To meet the MRDAs in these menus, additional snack and dessert items, as well as a calcium-fortified, high energy cocoa beverage powder were incorporated.

Many food manufacturers provided incomplete nutrient data for their products and nutrient data was missing for many

products in the USDA nutritional data base. Therefore, the following nutrients -- magnesium, zinc, vitamins B-12, B-6, E and folacin -- were analyzed using available data, but not included in the overall nutritional evaluation of these menus.

Conclusions and Implications

Due to the short duration of ODS, the final, nutritionally complete and unitized MORE (CT) was never procured for shipment to Southwest Asia. Nevertheless, prior to the completion of the MORE menus, pallets of selected commercial products were shipped in bulk to Southwest Asia to alleviate potential shortages of military rations. However, the lack of unitization, as well as logistical and distribution problems, prevented the troops from consistently receiving a complete meal. Consequently, their nutritional requirements for that meal (approximately one third of the MRDA) were not met when the commercial products were issued. As an interim solution to solve the distribution problem, a 24-person module containing two complete MORE (CT) menus per module was to be unitized for future procurement and shipment. Again, due to the short duration of ODS, this was not implemented.

Unlike the MORE (CT), approximately 10,000 Kosher MORE-MF meals were distributed to the troops in Southwest Asia in time

for Passover 1991.

The development of military rations presents unique challenges. The development of a commercial military meal poses even greater challenges. Unlike commercial products, standard military foods and rations are formulated/designed to meet the MRDAs, shelf life requirements and additional functionality/utility required by the military services. The food technologist must design and develop rations that are shelf stable, easy to prepare, highly acceptable, nutritionally complete, have low weight/volume and maintain primary/secondary packaging integrity in various tactical/environmental extremes. When compared to military ration components, many commercial food products are higher in sodium, lower in calories, are bulkier, have shorter shelf lives and inadequate packaging. In addition, unlike the MRE, the More (CT) is not intended to be stored for long periods of time (such as prepositioned war reserves) prior to its consumption by the individual service member. Nonetheless, when properly designed, assembled, stored and distributed, the added variety of the MORE (CT) could augment military rations and prevent decreased food consumption by reducing menu fatigue. Studies have shown that menu fatigue can lead to reduced intake over time which could impair soldier performance. (8,9,10). Also, recognizable, familiar foods may

improve morale by providing the soldier with a "little bit of home."

Fourteen shelf stable Kosher and vegetarian meals were developed under this project. The results of this effort were presented in May 1992 to a Joint Working Group (JWG) meeting composed of representatives from the Armed Forces Chaplain Board, Department of the Army, Office of the Deputy Chief of Staff for Logistics and the U.S. Army Quartermaster Center and School. The JWG determined that a separate meal comprised of commercial items or military specific components is not logistically feasible or cost effective. The JWG recommended that one meal in the MRE be adjusted with appropriate components to satisfy the nutritional needs of the majority of the religious/secular groups, as this would be cost effective. As a result, MRE specifications are being reviewed to identify adjustments required (such as formulation and/or ingredient types) to meet these dietary restrictions.

Future plans include testing the MORE rations to determine their actual shelf life, overall acceptability, transportability, packaging, unitization, handling, heating characteristics, and nutritional adequacy based on consumption and performance. Furthermore, as a result of ODS, a data base of commercially available foods with information inherent to military usage and handling was established to support potential

implementation of a nutritionally complete commercial ration concept. This data base will be continually updated as part of the Go-to-War Ration Program for use in future contingencies. In addition, a packaging and packing document will be provided to the Defense Personnel Support Center to enable the assembly of the MORE (CT) and eliminate distribution problems.

This Go-to-War Ration system, specifically the MORE (CT), will preclude potential production shortfalls during the lag time required for full-scale production of operational rations; it will optimize the assembly, transportation and distribution of the MORE; and will ensure each individual service member receives a nutritionally complete meal.

This document reports research undertaken at the U.S. Army Natick Research, Development and Engineering Center and has been assigned No. NATICK/TR-~~95~~⁹⁵/005 in the series of reports approved for publication.

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